# ERGONOMIC IMAGE RECORDER

The invention relates to image sensors of small dimensions.

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The application more especially aimed at here is image capture inside the human body, which requires such sensors. There is in particular a need for dental radiological sensors which are introduced into the
10 mouth of a patient to allow radiological observation of his jaw and his dentition. The ergonomics of use and the comfort of the patient are very important elements to be taken into account in the production of these sensors.

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The image sensor is an electronic sensor with matrix structure, consisting of an array of rows and columns with a photosensitive dot at the crossover of each row and each column. Electronic circuits are provided on
20 the sides of the matrix to ensure the operation thereof and in particular lateral registers for controlling the row conductors and a register at the bottom of the columns for ensuring the reading of the signals detected by the individual circuits. In the case of a
25 radiological sensor, the array is covered with a scintillator to convert X-rays into light and the luminous image resulting therefrom is detected by the array of photosensitive dots.

30 The matrix structure of the image sensor is in general made on a semiconductor chip of square or rectangular shape as is done for almost all integrated circuits. However, to improve the ergonomics, a proposal has already been made to make the sensor on a chip with
35 beveled corners. After encapsulation of the chip in a protective package which hugs the shape of the chip and rounds off the corners, the sensor has a shape which is more comfortable for the patient than if the chip were

rectangular.

Figure 1 represents a chip two corners of which are beveled; these are the corners situated "at the top" in the figure, in principle at the front of the sensor in the direction of introduction of the sensor into the mouth of the patient. The signals detected by the matrix are dumped vertically from the matrix to a horizontal reading register situated at the bottom of the matrix, hence here on the rear side in the direction of introduction of the sensor, just where there are no beveled corners. The charges are then dumped horizontally by the horizontal register to an output of this register. This solution is effective in respective of comfort while introducing the sensor into the mouth; it is less so in respect of comfort while removing the sensor from the mouth.

This is why one also seeks to make a sensor having a chip with four beveled corners, that is more ergonomic both in respect of introduction into the mouth and in respect of removal. However, the room required to place a reading register at the bottom of the matrix is then no longer available.

A solution to this problem has been proposed in patent US 5 510 623. It consists in placing a reading register vertically in the middle of the matrix, as is represented in figure 2, rather than horizontally at the bottom of the matrix.

In that case, the charges are dumped horizontally from the two half-matrices, left and right, to the central vertical register, then they are discharged by the vertical register to a central output situated at the bottom of the sensor. The ergonomics of the sensor is optimized by virtue of the four beveled corners, but the image is perturbed in the central zone of the

sensor on account of the presence of the vertical register, even if the vertical register is itself photosensitive.

5   The invention proposes a solution for deriving maximum benefit from the ergonomic advantages of a chip with four beveled corners without perturbing picture capture at the center of the matrix.

10  For this purpose, the invention proposes an image sensor comprising a matrix of rows and columns of photosensitive dots, made on a chip of general square or rectangular shape with beveled corners, characterized in that it comprises a reading register
15  placed at the bottom of the matrix, this register being bent so as to run alongside the beveled corners of the chip and therefore comprising a horizontal part and two oblique parts, and the sensor furthermore comprising means for directing photosensitive charges of columns
20  terminating opposite the beveled corners to register stages situated in the oblique parts alongside the beveled corners.

The means for directing the charges to the oblique part
25  of the register include in particular insulation zones between columns of the matrix, these zones being bent so as to aid the transfer of charges to the oblique part of the register. Moreover, certain of the row electrodes which serve for the transfer of charges in
30  the vertical direction, and which extend linearly in the shape of a horizontal strip along the matrix, are preferably bent at their end so that at the crossover of a row end and a column end in immediate proximity to the oblique part of the register, the end of the last
35  electrode comprises a part extending parallel to the oblique part of the register. The electrodes which immediately precede this last electrode have shapes intermediate between a horizontal strip and the bent

strip constituting the end of the last electrode so as to facilitate the transfer of charges to the oblique part of the register.

5    The reading register may have an output situated on the right or on the left. However, it preferably has a central output, that is to say it is divided into two half-registers operating in opposite senses so as to bring the charges from the left half of the matrix to

10    the right and the charges from the right half to the left. The register may in this case have either two central outputs side by side, one for each half-register, or a single central output, the charges of the two half-registers being dumped alternately to one

15    and the same reading circuit which multiplexes the signals arising from the two half-registers.

The presence of a register along a beveled corner in a matrix structure modifies the order of succession of

20    the signals extracted from the matrix, and requires that this order be restored during the utilization of the signals for the reconstruction of a global image. Means of reconstruction of the order of the image dots, as a function of the exact configuration of the beveled

25    corners and of the register which follows their contour, must therefore be envisaged, either on the sensor itself (on the chip) or off the sensor.

Other characteristics and advantages of the invention

30    will become apparent on reading the detailed description which follows and which is offered with reference to the appended drawings in which:
-    figure 1, already mentioned, represents a dental image sensor whose chip comprises two beveled corners;

35    -    figure 2, likewise already mentioned, represents a sensor whose chip comprises four beveled corners;
-    figure 3 represents the principle of a sensor according to the invention, with a lateral output of

the "horizontal" reading register;

- figure 4 represents a sensor with two central outputs;

- figure 5 represents a sensor with a multiplexed single central output;

- figure 6 represents the basic shape of the electrodes allowing dumping of the charges .into the output register at the level of the beveled corners;

- figure 7 represents an embodiment detail in the case where the columns of the matrix operate as a charge transfer register with four electrodes per register stage;

- figure 8 represents the metallic conductors intended for conveying the control signals to the various row electrodes of the matrix of figure 7.

The invention will be described in regard to an intraoral dental radiological sensor although it is applicable to other cases where similar problems of bulkiness, comfort and ergonomics would arise.

Figure 3 represents an electronic chip 10 according to the invention, intended to be encapsulated in a package substantially hugging the shape of the chip; the electronic chip comprises four main sides, top, bottom, right, left, which are pairwise perpendicular, and it exhibits four beveled corners which interrupt the main sides before they cross one another. The chip will be mounted on a base (not represented), of the same rectangular shape with four beveled corners, and it will be linked to this base by bonding wires internal to the package and soldered on one side to the base and on the other to the bonding pads 12 provided on the chip. The chip and base assembly is enclosed in a leaktight package (not represented) which hugs the rectangular shape with beveled corners of the chip and of the base and which preferably has rounded corners for comfort and ergonomics. Bonding wires for

connection to the outside, linked to the base, exit
this package, on one side only which is preferably but
not necessarily the bottom side of the figure, so that
a single bundle of wires, not represented, situated at
5    the bottom of the sensor, leaves the sensor so as to be
linked to an outside apparatus; these wires serve for
the electrical supply to the sensor and for gathering
the electrical signals representing the image detected
by the sensor; for an intraoral sensor, this bundle of
10   wires    exits    the    mouth    of    the    patient    during
radiological    picture    capture    of    the    inside    of    the
mouth; the top side of the figure is the upstream side
in the direction of introduction of the sensor into the
mouth of a patient.
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The sensor is a matrix sensor consisting of an array of
rows    and    columns    of    photosensitive    dots,    each
photosensitive    dot    gathering    electric    charges    in
proportion to the exposure of this dot to light. The
20   active    zone    proper,    comprising    these    photosensitive
dots, is a zone 14, of rectangular shape with beveled
corners like the shape of the chip, represented here by
its perimeter shown dashed. Around this zone are housed
the electronic circuits necessary for the operation of
25   the    matrix,    and    in    particular    the    registers    for
controlling rows. The active zone therefore comprises a
bottom side, a top side, a right side and a left side,
which are the four sides that may be referred to as
rectangular,    and    it    also    comprises    a    bottom    left
30   beveled    corner,    a    bottom    right    beveled    corner,    a    top
left beveled corner, and a top right beveled corner.

The angles of the beveled corners depend on the ratio
between the spacing of the rows and the spacing of the
35   columns    of    the    matrix.    Preferably,    the    spacing    is    the
same    row-wise    and    column-wise    (for    example    20
micrometers) and the beveled corners are then 45°, this
being the easiest to produce.

The electric charges gathered by the photosensitive
dots are transferred vertically column-wise to the
bottom of the matrix where they are dumped into a
5     reading register (that will be referred to as a
"horizontal" register by analogy with the customary
reading registers which are disposed horizontally at
the bottom of the matrix); dumping is effected
according to a conventional method consisting
10    -     in transferring the charges vertically from one
row to the next, simultaneously for all the rows of the
matrix, the last row being transferred into the
horizontal register,
-     in reading the row contained in the reading
15    register,
-     in performing a new vertical transfer step, and so
on and so forth.

According to the invention, the so-called "horizontal"
20    reading register 20, which transfers to an output the
charges that it has received after a step of vertical
shifting of the matrix, runs alongside the two beveled
corners of the bottom of the matrix. The register
therefore comprises a horizontal part 22 along the
25    bottom side of the active zone, and two oblique parts
24 and 26, respectively along the bottom left side and
along the bottom right side of the active zone. This of
course raises technical problems that will be detailed
hereinbelow. The charges of the various columns are
30    dumped not only into the horizontal part 22 of the
register, along the bottom side of the chip, but also
directly from the columns of the matrix to the oblique
parts 24 and 26 of the register.

35    In a first embodiment, represented in figure 3, the
reading register comprises a single output situated at
the distal end (furthest from the horizontal part 22)
of the oblique part 24 (or 26) of the register.

In a second embodiment, represented in figure 4, there are two half-registers 20' and 20'', one on the left, the other on the right; each half-register comprises a half of the horizontal part and a respective oblique part, left for the half-register 20', right for the half-register 20''. The half-registers may have outputs at the ends of the oblique parts, in a configuration much like that of figure 3 but with two symmetric outputs. However, they may also have outputs side by side, at the adjacent ends of the halves of horizontal parts of the registers, hence at the center of the bottom side of the matrix, as is represented in figure 4.

In a third embodiment, represented in figure 5, the two half-registers 20' and 20'' have a single output at the center of the bottom side of the matrix, and this output provides alternately, in a multiplexed manner, the charges originating from the left side and from the right side of the matrix of photosensitive dots. The signals must thereafter be demultiplexed to reconstruct an image line.

The first embodiment allows a simple layout of the register and simplifies the design of the control of the register. However, it does not make it possible to optimize the use of the chip zone available between the left (or right) edge of the active zone and the left (or right) edge of the chip.

The second embodiment makes it possible to bring the edge of the active zone closer to the left or right edge of the chip, hence to increase the area of the image capture zone for one and the same chip area, but it compels a complication in the layout of the output of the registers. Moreover, the existence of two outputs entails a risk of imbalance between the left

half and the right half of the image. Also the consumption of the outputs is bigger.

The third embodiment also makes it possible to bring
5   the edge of the active zone closer to the edge of the chip. The layout of the output is simpler than in the second solution. This third solution makes it possible to optimize the dimensions of the chip, to circumvent certain dispersions in gain between different outputs,
10  and to minimize consumption by virtue of the use of a single reading amplifier.

Figure 6 represents a schematic layout of electrodes making it possible to efficiently dump the charges into
15  a bent register from columns which do not arrive perpendicularly to the register in the oblique parts of the latter.

The reading register 20 is represented in its part
20  situated at the corner between the horizontal part 22 and the oblique part 26 of the register.

The matrix of the active zone has horizontal rows $L_m$, $L_{m+1}$, for the rows of rank m and m+1 respectively etc.,
25  and to simplify the explanations it has been assumed, in the case of figure 6, that each row comprises two electrodes only: an electrode Ea of type a, an electrode Eb of type b (electrodes $Ea_m$, $Eb_m$ for the row of rank m, $Ea_{m+1}$, $Eb_{m+1}$ for a following row). The
30  electrodes are all intimately adjacent to one another in order to effect the charge transfers. It is also assumed for simplicity that the last electrode $Eb_M$ of the last row of the matrix, that is to say the row of rank M, closest to the reading register, is immediately
35  adjacent to the reading register.

The matrix also has vertical columns $C_n$, $C_{n+1}$, etc., mutually insulated (typically by P-type diffusions when

the charge transfer and storage surface zones are of N
type) so as to avoid a lateral transfer of charges,
these columns behaving, by virtue of the row
electrodes, as vertical shift registers, that is to say
5   that during a phase of reading of the image stored in
the matrix in the form of electric charges, the charges
of the pixels of a column are shifted vertically row by
row in this column and the charges of the last row are
dumped at the end of the column.

10

Whereas over the whole of a conventional matrix the row
electrodes    are    horizontal    straight    strip-like
conductors over the entire length of the matrix, with a
single    electrode    of    type    b    $(Eb_m)$    adjacent    to    a
15   horizontal register over its entire length and a single
electrode    of    type    a    $(Ea_m)$    adjacent    over    its    entire
length to the electrode $Eb_m$, it is seen that here it is
necessary to adopt a special design of electrodes of
type a and of type b or a special design of the reading
20   register in order that a succession of two electrodes
of type a then b is adjacent to the register even in
the oblique part of the register.

The reading register could rise staircase fashion along
25   the oblique edge of the matrix zone; this staircase
configuration would have the advantage of permitting
the electrodes of type a and of type b to remain
theoretically    straight    over    their    entire    length,
including at their end adjacent to the oblique part 26
30   of    the    reading    register.    However,    a    staircase
configuration of the reading register is less effective
in respect of charge transfer.

In figure 6, the register has by choice been given a
35   straight    rather    than    staircase    configuration    in    its
oblique part 26. A particular configuration is then
given to the ends of row electrodes which terminate at
the    register.    Moreover,    the    vertical    transfer    of

charges to the register is aided by turning the columns toward the register. This is done by bending perpendicularly to the register the insulation zones which separate the columns from one another (these insulation zones are symbolized by the dotted lines in figure 6).

It is assumed, in figure 6, that the column $C_n$ of rank n terminates at the register at the location where the row $L_{m+1}$ of rank m+1 terminates at the register. That is to say, it is row $L_{m+1}$ which constitutes the last row into which the charges of column $C_n$ will be transferred before these charges are dumped into the register; and these charges will then be transferred into a stage $ET_n$ of the register, dedicated to column $C_n$. More precisely, it is electrode $Eb_{m+1}$ which constitutes the last electrode in column $C_n$; the electrode $Ea_{m+1}$ constitutes the last but one electrode.

We shall be concerned only with the columns of the right half-matrix, it being understood that the left half-matrix is generally symmetric with the right half-matrix.

The electrode $Eb_{m+1}$ of row $L_{m+1}$ is straight and parallel to the horizontal part 22 of the reading register, except at its end; that is to say this electrode is straight and horizontal when it crosses the successive columns up to rank n-1, but it ceases to be straight, in the configuration of figure 6, when it crosses the column of rank n.

At this location, the end of the electrode $Eb_{m+1}$ of row $L_{m+1}$ is bent in such a way that a part of the electrode now extends parallel to the stage $ET_n$ of the oblique register 26. The bend is firstly a downward bends, perpendicular to the oblique part of the register, then an upward bend parallel to the register.

In the same way, the shape of the electrode $Ea_{m+1}$ is that of a straight strip while it crosses the columns of the matrix up to the column of rank n-1; however, at
5   the location where it crosses the column of rank n, it adopts another shape, such that it remains intimately adjacent both to the straight electrode which immediately precedes it (here: $Eb_m$) on one side and to the bent electrode $Eb_{m+1}$ on the other side.
10

In the direction of the shifting of charges in the oblique zones of the reading register, the spacing of the stages of the register is increased all the more when the inclination of the beveled corner is large.
15   For a 45° beveled corner, the spacing is increased in the ratio square root of 2. The horizontal register is itself composed of a succession of mutually adjacent electrodes (for example two or four electrodes per stage of the register); these electrodes are not
20   represented in figure 6; they are wider in the oblique part 26 of the register, just where the spacing of the registers is widest, than in the horizontal part 22.

The register stage constituting the transition where
25   the register passes from a horizontal configuration to an oblique configuration, here the stage referenced $ET_{n-2}$ may be larger than the other stages (lengthwise in the direction of flow of the charges in the register) as is represented in figure 6. However, it may be
30   preferable to cut it into several elements, for example into two half-stages, the transfer of charges in the register not being as good if the register electrodes are too wide (width in the direction of flow of the charges). However, if stage $ET_{n-2}$ is cut into two, it
35   will be understood that only one of the two half-stages has to receive charges from the column (here column $C_{n-2}$) which emerges opposite stage $ET_{n-2}$. An insulation barrier (p+ diffusion for example) is therefore placed

in front of the other half-stage so as to separate it from the adjacent columns ($C_{n-2}$ as much as $C_{n-1}$). This half-stage receiving no charges from the columns, this must be taken into account when utilizing the signal
5  output by the horizontal register: a "hole" will be present in the series of pixel values that emanates from the register, this hole corresponding to a virtual site between the columns $C_{n-2}$ and $C_{n-1}$. If the register's horizontal stages comprise two electrodes, the two
10 half-stages constituting stage $ET_{n-2}$ also comprise two electrodes each.

In figure 6, for ease of explanation, ends of electrodes of type b that are mutually independent have
15 been represented. However, in a column-wise charge transfer register, all the electrodes of type a are controlled simultaneously and all the electrodes b are controlled simultaneously. The arrangement of figure 6 makes it possible to link the electrodes of type b to
20 one another, forming a single continuous electrode along the oblique part of the register since they are practically adjacent to one another just where they run alongside this oblique part. Such is not the case for the electrodes of type a which remain physically
25 separated from one another but which have to be linked together electrically by other means that will be detailed later.

With a register thus configured with a horizontal part
30 and an oblique part, a problem of utilization of the signals gathered by the reading register arises. Specifically, although conventionally on each occasion the reading register dumps to an output the signals corresponding to an image line, here there is a mixing
35 of information between different rows.

If $S_{m,n}$ denotes the signal gathered in the photosensitive dot at the crossover of a row of rank m

and of a column of rank n, a conventional reading register would provide the following signals in order in succession, assuming that only the right half of the matrix (columns 1 to N) is of concern and that the
5 output of the register occurs towards the right:

$$-S_{M,1}, \ S_{M,2}, \ \ldots\ldots\ldots\ldots\ldots S_{M,N}$$
$$- \text{ then } S_{M-1,1}, \ S_{M-1,2}, \ \ldots\ldots\ldots\ldots S_{M-1,N}$$
$$- \text{ then } S_{M-2,1}, \ S_{M-2,2}, \ \ldots\ldots\ldots\ldots S_{M-2,N}$$
10 etc.

However, in the invention, the order of the signals is shuffled, the information transmitted being in succession:

- firstly the information $S_{M,1}$, $S_{M,2}$, ... of row $L_M$ in
15 the order of the columns for all the columns which are opposite the horizontal part of the register, then $S_{M,n-2}$, $S_{M-1,n-1}$, $S_{M-2,n}$, etc. if it is assumed that the oblique part of the register commences onward of column n-1,

20 - then the information $S_{M-1,1}$, $S_{M-1,2}$, .... of row $L_{M-1}$ in the order of the columns for all the columns which are opposite the horizontal part of the register, then $S_{M-1,n-2}$, $S_{M-2,n-1}$, $S_{M-3,n}$, etc.
- and so on and so forth.

25

Means (in principle a buffer memory) for reorganizing the order of the signals so as to allow the reconstruction of the image are therefore provided in the sensor or preferably outside the sensor.

30

Figure 7 represents a practical exemplary embodiment in the most general case where each row of the matrix comprises four adjacent electrodes controlled by signals allowing the progressive shifting of charges
35 from one row to the next. In this example, the reading register also comprises four electrodes per register stage. Only a portion of oblique part 26 of the reading register is represented, with the intersection of two

rows $L_m$, and $L_{m+1}$ and of two columns $C_n$ and $C_{n+1}$.

Each row comprises four electrodes, $Ea_m$, $Ea'_m$, $Ea''_m$,
and $Eb_m$ for row $L_m$. The columns are delimited by
5    insulation zones $ZI_n$, $ZI_{n+1}$, which channel the charges
vertically inside a column and which are bent at their
end perpendicularly to the register so as to channel
the charges obliquely towards a respective stage $ET_n$,
$ET_{n+1}$ of the reading register. The column end into which
10    the transferred charges pass is therefore bent
perpendicularly to the oblique register.

Just where a column and a row finish opposite a stage
of the oblique part of the reading register, the four
15    electrodes are deformed and cease to consist of a
simple straight strip of constant width:
- the electrode $Eb_m$, which is a straight strip provided
that it has not arrived in front of the last column of
rank n+1 is bent obliquely downwards (above the
20    insulation zone $ZI_n$) then obliquely upwards above
column $C_{n+1}$, the upward bend constituting an electrode
portion which runs alongside the oblique register; all
the electrodes $Eb_m$ are preferably attached to one
another in the form of a single oblique conductor Eb
25    which runs alongside the oblique register and which
groups together all the obliquely upward bent parts of
the electrodes $Eb_m$;
- the electrodes $Ea_m$, $Ea'_m$, $Ea''_m$ have intermediate
shapes making it possible to pass progressively from
30    the horizontal straight strip shape of constant width
possessed by electrode $Eb_{m-1}$ in the column $C_{n+1}$ to the
oblique strip shape of electrode $Eb_m$ is this same
column.

35    In this embodiment matters have been contrived such
that the electrodes of row $L_m$ cease to have a straight
strip shape only when they arrive in the last column
$C_{n+1}$ but it would be conceivable for the deformation of

the electrodes to commence slightly before, for example when they are still in the last but one column $C_n$, so as to facilitate, inside this column, the progressiveness of deformation of the electrodes from a
5    horizontal strip shape to an oblique strip shape.

The reading register has in this example four electrodes per stage $E1_n$, $E2_n$, $E3_n$, $E4_n$ for stage $ET_n$. The charges originating from the column of rank n are
10   dumped under electrode $E2_n$ when the latter is at an appropriate potential; all the electrodes $E2_n$, $E2_{n+1}$, etc. are joined together by a conductor EC2 extending along the reading register parallel to the conductor Eb.
15

In a conventional matrix, the control signals for the row electrodes would be conveyed via the ends of these electrodes on one side of the matrix. However, in the matrix according to the invention there is a difficulty
20   since the ends of the electrodes are not easily accessible from the side of the matrix, just where these electrodes terminate in front of the oblique part of the register; this being so neither on the right nor on the left.
25

This is why provision is made for access metallizations of these electrodes to pass along the oblique register, above the electrodes, and to come into point contact with the electrodes that have to be powered. In the
30   register with four electrodes per row of figure 7, provision is preferably made for four metallization lines Ma, Ma', Ma'', Mb which run along the oblique register so as to come into contact respectively with the electrodes Ea, the electrodes Ea', the electrodes
35   Ea'', and the electrodes Eb. These lines are represented in figure 8.

These metallizations (preferably aluminum) must occupy

as little room as possible since they mask the photosensitive zones situated along the reading register. Matters may be contrived such that in total they mask only one or two rows of photosensitive dots.

Figure 8, superimposable on figure 7, shows the metallization lines that may be provided, and the zones where they contact the row electrodes so as to apply the desired control signals to them. The electrodes mentioned with reference to figure 7 are represented dotted in figure 8. The metal conductors which convey the control signals to them are represented as solid lines. The contact zones between a metal conductor and an electrode situated underneath (and insulated by an insulating layer interrupted at the location of the contacts) are represented by a square barred with a cross. The layout of the conductors is such that there is compliance at one and the same time with a sufficient width of the conductors (to ensure sufficient conductivity), a sufficient width at the location of the contacts (to avoid contact faults) and a sufficient gap between conductors (to avoid short-circuit faults).

There is point contact between the metallization Ma and the electrodes $Ea_m$, $Ea_{m+1}$, etc., at points $A_m$, $A_{m+1}$, etc.

There is point contact between the metallization Ma and the electrodes $Ea'_m$, $Ea'_{m+1}$, etc., at points $A'_m$, $A'_{m+1}$, etc.

There is point contact between the metallization Ma'' and the electrodes of even rank $Ea''_m$, $Ea''_{m+2}$ etc. but not between the metallization Ma'' and the electrodes of odd rank $Ea''_{m+1}$, if there is insufficient room (but more room could possibly be created by distancing the conductors Ma, Ma', Ma'', Mb from one another or by using a different configuration). If the contact is not

made with the electrodes of odd rank, provision must of course be made for contact with these electrodes at some other location, and this other location is quite simply the other side of the matrix (left side); specifically, the conductors Ma, Ma', Ma'', Mb extending along the whole of the reading register both in its horizontal part and in its two oblique parts.

Finally, from place to place the metallization Mb contacts, at points $B_m$, the common electrode Eb which is linked, it will be recalled, to the electrodes $Eb_m$, $Eb_{m+1}$, etc. Provision need not be made for contact having the same periodicity as the spacing of the rows. In the example represented, contact is made one row out of two.

The matrix sensor thus made is covered with a scintillating layer before encapsulation if one wishes to make a radiological sensor, and in particular to make an intraoral dental radiological sensor.